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AN INTERREGIONAL INPUT-OUTPUT ANALYSIS OF THE EASTERN CANADIAN ECONOMIES

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(Revised)

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The relative openness of the economies of the Atlantic Provinces vis-a-vis the Rest of Canada has important implications for the design of economic policy in Canada and in its constituent parts. This paper reports on the quantification of the relative openness of the economies of Atlantic Provinces by means of the Chenery-Moses interregional input-output model. Federal Government policies such as those executed by the Atlantic Development Board and the Area Development Agency for purposes of developing industry in the Maritimes are briefly evaluated in light of the results derived on the structure of economic activity in the Atlantic economies. Transportation subsidization policies in effect under the Maritime Freight Rates Act, passed in 1927, are also briefly evaluated.

The Chenery-Moses[1] interregional input-output model is an interregional general equilibrium framework of a system of economies. The models can be empirically articulated with data on interregional and intersectoral commodity flows. Given a statistically implemented model we can run certain experiments in comparative statics and determine multiplier effects. Of course the multipliers so derived are only valid within the confines of the assumptions of the model. With minor exceptions, we will not discuss these assumptions here since they are well discussed elsewhere.[2]

The particular merit of interregional input-output models is that they can capture intersectoral <u>and</u> interregional feedback effects in the same way that single region input-output models capture intersectoral feedback effects. Increases in activity in region A not only lead to increases in activity in regions B and C, but those increases induced in B and C feedback on region A and so on until a new equilibrium is obtained. The measures of links between the economies of the Atlantic Provinces or multipliers reported below incorporate these feedback effects.

In summary, the results reported below reveal that multiplier effects of expenditure in each of the Maritime Provinces are smaller than similar effects in the Rest of Canada. These results can be attributed to the fact, also reported, that leakages of economic flows from each of the Atlantic Provinces' economies are, relative to the size of the economies, much larger than leakages of economic flows from the Rest of Canada to each of the economies of the Atlantic Provinces. A disaggregation of these multiplier effects and leakage effects into fifteen industrial sectors is reported. We then observe relatively high leakages of economic flows from sectors in the Maritime economies associated with manufacturing or secondary industry. Although none of these results is startling, it is of some interest to precisely quantify them through the use of an empirically articulated general equilibrium model as we do below.

To be more specific, input-output analysis has often dealt with the question: What are the gross outputs or activity levels x (a vector) which sustain a specific final demand vector y? In applied work, the answer has been to construct a square matrix, A, of technical coefficients from observed intra-regional intersectoral flows and to determine x by solving the system $x = (I-A)^{-1} y$, where I is the identity matrix and $^{-1}$ indicates the inverse. In interregional input-output analysis we are concerned with solving for a vector x^I of activity levels or gross outputs in many sectors and <u>in many regions</u> when a final demand vector y^I is prescribed and where y^I indicates the levels at which final demands for the same many sectors and the same many regions are set. We can compute an interregional input-output analogue A^I to A above[3] and solve the system $x^I = (I^I - A^I)^{-1} y^I$. Not only are indirect demands by sector taken into account in an interregional input-output model as they are in the single region Leontief model, but interregional feedbacks from activity in one region to that in another are taken into account.

In Section 1 is a review of the Chenery-Moses procedure for computing the matrix A^I and in Section 2 are reports on the various solutions for x^I in a six-region application of the model to Canada when different y^I are prescribed. By appropriately interpreting the components of the x^I's, we determine interregional multiplier effects in Canada.

The six regions analyzed in this study are: New Brunswick (NB), Nova Scotia (NS), Newfoundland (Nfld), Prince Edward Island (PEI), the Rest of Canada (R of C), and the Outside World (OW). The first five regions are endogenous to the structure which implies that imports from one region to another have feedback effects from the supplying region to the receiving region as well as to other regions in the model. Imports from the Outside World are exogenous and elicit no increases in activity levels in any Canadian region by feedback effects. The particular regions were chosen because I was interested in the economic links between Canada's Atlantic regions and the Rest of Canada, a question of enduring interest to many Canadians owing to the persistent failure of the Atlantic regions to perform as well economically as the other parts of Canada,[4] and because input-output data for the Atlantic Provinces have recently become available for the year 1960. The data were prepared by researchers under the supervision of Professor Kari Levitt[5] under contract with the Dominion Bureau of Statistics and the Atlantic Development Board.

I. THE CHENERY-MOSES INTERREGIONAL INPUT-OUTPUT MODEL

In this exposition of the Chenery-Moses model, we will review the techniques for constructing a coefficient matrix A^I analogous to a Leontief matrix A (not I-A). This model is designed to be statistically implementable with the data available in Table 1 and the additional flow matrices described following the table. The essential feature of the data that can be recorded in the accounting framework in Table 1 is that inherent in them is the fact that we know the region of origin of flows by sector.

Table 1

	Region 1	Region l	Region m	Final Demand	Total
Region 1	x^{11}	x^{1l}	x^{1m}	y^1	x^1
	$\cdot$	$\cdot$	$\cdot$	$\cdot$	$\cdot$
	$\cdot$	$\cdot$	$\cdot$	$\cdot$	$\cdot$
Region k	x^{k1}	x^{kl}	x^{km}	y^k	x^k
	$\cdot$	$\cdot$	$\cdot$	$\cdot$	$\cdot$
	$\cdot$	$\cdot$	$\cdot$	$\cdot$	$\cdot$
Region m	x^{m1}	x^{ml}	x^{mm}	y^m	x^m
Primary Inputs	$g^{1'}$	$g^{l'}$	$g^{m'}$		

where

x^{kl} is a column vector with n components, x_i^{kl}, $i = 1, \ldots, n$.

x_i^{kl} is the flow of commodity i from region k to region l.

y^k is a column vector with n components, y_i^k, $i = 1, \ldots, n$.

y_i^k is the final demand in region k for commodity i. It includes exports to regions not included in the set of m regions, but excludes consumption which is assumed to be one of the n activities within the system.

x^k is a column vector of n components, x_i^k, $i = 1, \ldots, n$.

x_i^k is the total output of i from region k including exports to other regions plus final demand in region k.

$g^{l'}$ is a row vector of n components, g_j^l, $j = 1, \ldots, n$.

g_j^l is the primary inputs including non-competitive imports and indirect taxes. Households are assumed endogenous so that wages and salaries are considered as one of the n activities within the vectors in the upper left hand part.

In addition to the flows in Table 1 it is assumed that we know a matrix X^{kk} for each region $k = 1, \ldots, m$ which contains intersectoral flows from each of n sectors to each of n sectors aggregated to include all competitive imports. Thus x_{ij}^{kk}, the i,j^{th} component of X^{kk} describes the total amount of i including imports required to produce an observed output of j.

Chenery and Moses independently arrived at the same procedure for constructing an operator matrix A^I. In the absence of knowledge of the destination by sector of the interregional flows, Chenery and Moses developed proxies for such flows. They suggested consigning interregional flows to sectors through the use of the known intersectoral flows as weighting coefficients. That is, partition the aggregated interregional flows into intersectoral interregional flows through the use of coefficients derived from the known intersectoral flows.

Chenery and Moses have expressed the following economic interpretation of their procedure. All producers in, say, region A consider the imports from a specific sector in a region B as homogenous with respect to the output of the same sector in regions C and D. Thus if sectors ten and eleven in region A import say, 9 and 12 million dollars worth of bricks from regions B and C respectively then if sector ten imports 3 million dollars worth from region B and 6 million dollars worth from region C, sector eleven must import 4 million dollars worth from region B and 8 million dollars worth from region C. That is the relative proportions are the same for all producers. The assumptions implicit in this procedure approximate reality and thus the flows derived from the procedure approximate actual intersectoral interregional flows. The procedure is used because data are in general and in the case of this study, not available for the sector and region of destination as well as for the sector and region of origin.[6]

The coefficients of the Chenery-Moses matrix operator are defined as follows:

$$(s_i^{kl})\ (a_{ij}^k) = \left[\frac{x_i^{kl}}{\sum\limits_{k=1}^{m} x_i^{kl}}\right] \cdot \left[\frac{x_{ij}^{kk}}{\sum\limits_{i=1}^{n} x_{ij}^{kk} + g_j^k}\right]$$

where x_{ij}^{kk} is the i,j^{th} component of X^{kk}, and g_j^k is the j^{th} component of $g^{k'}$. The terms on the right hand side in each bracket in (1) correspond to the coefficients on the left hand side in each respective bracket.

Consider the second coefficient first. It is a technical coefficient in the sense that it defines the total amount of flow i required per unit output of j in region k. The coefficient s_i^{kl} indicates the fraction of commodity i supplied by region k to region l. Obviously summing over regions $\sum\limits_{k=1}^{m} s_i^{kl} = 1$ and if region k imports no i, $s_i^{kk} = 1$ with all other supply coefficients of commodity i related to region k equal to zero.

nm x nm components of a matrix A^I can be constructed using the definition (1) where each component of A^I will be composed of a supply coefficient and a technical coefficient. The usual way of arranging the components of A^I is to have m (for regions) n x n matrices along the diagonal of A^I operating to produce <u>intra</u>-regional flows and the (mxm)-m off diagonal matrices will operate to produce <u>inter</u>-regional flows. Each of the m column blocks of A^I will be composed of m matrices -- one of which will be an "intra-regional" matrix and the other matrices will be interregional operators regulating supplies or imports to the sectors in the one specific region whose "intra-regional" matrix is also contained in the particular column of matrices.

2. ESTIMATES OF INTERREGIONAL MULTIPLIER EFFECTS

The Chenery-Moses model was statistically implemented for the five Canadian regions - the four Atlantic Provinces plus the Rest of Canada. Each technical coefficient matrix for each region was 16 x 16 and the household sector was endogenous to each, being the sixteenth sector. The Canadian input-output table for 1949 which was updated to 1959 was used as the Rest of Canada's technical coefficient matrix. The Atlantic Provinces' tables, based on data for the year 1960, were prepared at the Atlantic Development Board. The principal interregional coefficient matrix which we have referred to as A^I above was 80 x 80, i.e. (5 regions x 16 sectors) x (5 regions x 16 sectors) after the coefficients were prepared.[7]

In order to estimate the multipliers, whose properties are discussed below, different constellations of final demands were set and the resulting activity levels computed.

First, final demands were set in six different ways, each of which we shall call an experiment. For each experiment the results were the response in activity levels or gross outputs and these were recorded in a 96 component vector composed of 6 sets of 16 sectors. The 6 sets correspond to six regions: The Rest of Canada, New Brunswick, Nova Scotia, Newfoundland, Prince Edward Island and the Outside World. Our model permitted us to derive imports by sector to each Canadian region from the outside world but not the exports of each region to the Outside World. There are no interregional feedbacks from the Outside World since its receipts (the exports of each region) were recorded in the final demand vector and were thus exogenous. That is, the provision of a certain supply by the Outside World made no demands on the other five regions in order to provide that supply.[8]

The six experiments were as follows:

(i) Set final demands in all sectors in all five Canadian regions at 100% of their observed values.

(ii) Set final demands in all sectors in the Rest of Canada at 100%; all other final demands being left at zero.

(iii) Set final demands in all sectors in New Brunswick at 100%; all other final demands being left at zero.

(iv) Set final demands in all sectors in Nova Scotia at 100%; all other final demands being left at zero.

(v) Set final demands in all sectors in Newfoundland at 100%; all other final demands being left at zero.

(vi) Set final demands in all sectors in Prince Edward Island at 100%; all other final demands being left at zero.

The selection of 100% as the proportional increase has little special significance since the model has the property of constant returns to scale; consequently any proportionate change in final demands will yield the same multipliers. Naturally, we do not really believe that the economic system implicit in our system of coefficients could sustain final demands increased by 100% over historically given values.

The fraction, change in gross outputs divided by a change in final demand, yields a multiplier. When many changes in final demands are made concurrently as in all our 6 experiments, the resulting multipliers are conditional, that is, the value of the multiplier in question is conditional on the values of all the other final demands. Note that the multipliers are different in each experiment not only because the regions in which the final demands impinge are changed but also because the conditional variables are altered from 100% changes to zero changes in different experiments.

Another way of considering the conditional nature of these multipliers is this. The elements of $(I-A^I)^{-1}$ are themselves multipliers, and we are considering linear combinations of these multipliers where the weights in the combination are all 100% changes. To see this, consider a unit change in final demand in sector 6 in Newfoundland, all other final demands left unchanged or with zero entries for this experiment. If this final demand regime consisting of one non-zero entry is multiplied by $(I-A^I)^{-1}$, an eighty-component vector is produced which indicates the change in activity levels in each sector in each region resulting from this unit change in final demand in sector 6 in Newfoundland. This eighty-component vector is simply a column of $(I-A^I)^{-1}$.

There are then 80 x 80 basic and unconditional multiplier elements. We are considering specific linear combinations of these elements in order to try to reduce the number of effects to be discussed and yet preserve the insights provided by the basic elements.

These multipliers are different from those in a Keynesian model. The difference does not turn on the conditional qualities of these multipliers since we can make these multipliers unconditional simply by setting all but one final demand zero, or alternatively we can make the Keynesian multipliers conditional by varying two or more exogenous variables together. The difference lies in the fact that the effects of an exogenous change in final demands are in gross output terms, that is, they include direct and indirect requirements, rather than in the net output terms of a Keynesian model based on the Kuznets' accounting principles. A national income multiplier in the Keynesian framework quantifies the effect of a change in an exogenous variable, say investment, on the output of the economy, net of all increases in activity which are required to produce the indirect outputs complementary to the final demands. The multipliers in an input-output framework include those indirect effects in total outputs.

The effects of the different experiments or gross outputs generated are presented in Table A1 in the Appendix.

We can calculate multipliers from our experiments. The results from this first experiment were aggregated over sectors and the results are reported in Table 2. We have then the effects or gross outputs in each region from a k percentage change in final demands in one region, divided by the value of final demands from the k percentage change for the region where the final demands are changed.

TABLE 2

Multiplers for k Percent Increase in Aggregated Final Demands in One Region on Its Own Aggregated Gross Outputs and on Other Regions Aggregated Gross Outputs

		Regions where effects impinge				
		R of C	NB	NS	Nfld	PEI
Regions where final demands are increased a constant percent	R of C	3.30	.03	.02	nil	nil
	NB	.28	2.50	.12	nil	.01
	NS	.33	.07	2.70	.07	.02
	Nfld	.36	.04	.05	2.50	.03
	PEI	.22	.10	.05	.03	2.60

Source: Data from Table A1 and A2.

Many of the general results of this study are captured in Table 2.

Let it be understood that an "own" effect or coefficient such as a multiplier will be the effect resulting or coefficient yielded from a change in a particular region's final demands <u>on itself</u>. An "own" multiplier will be the multiplier calculated from dividing the gross outputs or activity levels generated in a region by the final demands involved in the change in that region which generated the effects. We observe the fact that own multiplier effects in the Rest of Canada (3.30) are higher than for any of the Atlantic regions (2.50 for N.B. and Nfld. to 2.70 for N.S.). We also see that the aggregated multiplier effects on the Atlantic regions for changed final demands in the Rest of Canada are very small relative to the results from the reverse relationships. These results persist when absolute changes in final demands are examined.

We can measure the effects by using the domestic provincial product for the region where the effects impinge as the base rather than the value of the changed final demands in the region where the effects originate. Domestic provincial product means the value of a province's gross domestic product net of all exports to other regions. Values of Domestic provincial products are reproduced in the appendix, Table A2. These multiplier effects are contained in Table 3.

TABLE 3

Multiplier Effects with Receiving Region's Product as Base for k Percent Increase in Aggregated Final Demands in Separate Regions

		Regions where effects impinge				
		R of C	NB	NS	Nfld	PEI
Regions where Final Demands are increased a constant percent	R of C	3.30	1.30	.62	.15	.65
	NB	.007	2.50	.09	.006	.09
	NS	.01	.09	2.70	.11	.21
	Nfld	.006	.03	.029	2.50	.128
	PEI	nil	.015	nil	.006	2.60

Source: Data from Tables A1 and A2.

Note that the own multipliers are the same as those in Table 2. Both sets have the same region where changes in final demands originate and where changes in final demands impinge. The off-diagonal multiplier effects are different since in Table 3 they incorporate an own region final demand as the base for measuring the impact and in Table 2, on the other hand, they have the value of changed final demands in the region of origin.

We observe, from the results in Table 3, that the effects transmitted from the Rest of Canada to each of the Atlantic Provinces range, as proportions of domestic provincial product from .15 for Newfoundland to 1.30 for New Brunswick. Also the effects transmitted from each of the Atlantic Provinces to the Rest of Canada comprise relatively small fractions of the Rest of Canada's domestic product ranging in value from nil for Prince Edward Island to .01 for Nova Scotia.

The results in Table 3 indicate that the leakages of activity from the Rest of Canada to each of the Atlantic Provinces form relatively large proportions of the domestic provincial products of the Atlantic Provinces in spite of the fact that these leakages were relatively small fractions of domestic product for the Rest of Canada. Nevertheless, the proportion of domestic provincial product impinging on the Rest of Canada for each of the Atlantic Provinces is larger than the proportion of domestic product for the Rest of Canada impinging on any (and all) Atlantic Provinces. These results were not unpredictable since it has been observed that there is a strong negative correlation between the size of a region and the average propensities to import and export.[9]

In Table 4 are contained "own" multipliers for sectors derived from the data generated from experiments whose results are recorded in Table A1. For the Rest of Canada for example, the final demands were increased by

100 per cent in all sectors and the gross outputs were recorded for the Rest of Canada as well as the other regions. These changes in final demands, which are dollar flows and not percentages, were divided into the gross outputs generated in the region whose final demands were set sector by sector, i.e., sector 1's gross output was divided by sector 1's value of the change in final demand. The multipliers are presented in Table 3.

In Table 4, we observe sectors 2, 3, 4, 7, 8, and 16 all have a multiplier for one region or more which is very large relative to others in the Table. From considering all sectors, we note only sector 7's large value is not infinite or in the four digits. The infinite values indicate that there was no historically given final demand for that sector in that region. Thus in order to compute a multiplier, we must divide by zero and get an undefined value which we have labelled ∞.[10] The other large values display the characteristic that the 100 per cent increase in final demand was a small number in absolute value relative to the other final demand values, and we can, I believe, attribute the large multipliers to an inaccurate estimate of the 100 per cent change in those sectors. In other words, had a completely accurate value been used for the change, one with rounding after, say, four significant figures, then an accurate multiplier would have been estimated with a plausible magnitude. Data with the required degree of accuracy were not available. This explanation is based on the fact that no very high multiplier values were observed for sectors for which final demands were at least one million dollars and known with a possible error of less than 20 per cent.

If we ignore the extreme values of the multipliers, we observe that the order of magnitude for them in each sector for all regions is about the same. Only in sectors 6 and 9 is there a difference of the order of two

TABLE 4

Own Multipliers for Five Regions Derived from Experiments with Percentage Changes in Final Demands

Sector	Rest of Canada	New Bruns-wick	Nova Scotia	New found-land	Prince Edward Island
1. Agriculture	2.47	2.65	2.61	1.81	2.35
2. Forestry	18.50	2.08	3.35	3.19	1.32
3. Fishing	2.11	∞	21.91	∞	9.48
4. Mining, drilling, quarrying	2.99	2.15	2.16	1.03	∞
5. Food processing	1.50	1.39	1.52	1.38	1.40
6. Iron reduction and fabricating	2.73	1.19	1.17	1.14	1.05
7. Fabricating*	2.94	2.88	2.21	1.45	8.26
8. Sawmills and other wood industries	2.18	2.05	4.65	14.42	∞
9. Pulp and paper mills	2.07	1.05	1.13	1.01	1.00
10. Fish processing	1.29	1.04	1.03	1.11	1.06
11. Residential construction	1.59	1.83	1.57	1.60	1.50
12. Non-residential construction	1.25	1.01	1.19	1.11	1.11
13. Transportation	2.95	4.30	3.77	3.77	3.64
14. Radio broadcasting, electric power, gas and water	4.69	2.96	3.15	4.07	2.89
15. Trade and tertiary services	2.76	2.45	2.53	2.72	2.51
16. Households	∞	∞	∞	∞	∞

*including petroleum refining, printing and publishing, yarn and cloth mills, clothing, miscellaneous wood industries.

times one value. We might have conjectured that sector 6, iron reduction and fabricating, would have had a higher multiplier in the Rest of Canada than in any of the Atlantic regions since this activity would be highly integrated into activity in other sectors in the Rest of Canada. Nova Scotia has a large iron reduction establishment which includes the fabrication of such items as rails for railways but even without making a detailed study of the structure of industry in Nova Scotia, one is led to believe that this industry is very loosely integrated into economic activity in other sectors in Nova Scotia. However, the reason for the low multipliers for pulp and paper, sector 9, in the Atlantic regions vis-a-vis the Rest of Canada is difficult to explain. It probably hinges on the fact that the bulk of the basic chemicals required for processing pulp must be imported from the Rest of Canada. I leave it an open question requiring further intensive study.

3. CONCLUSION

The results of the regional analysis by interregional input-output techniques have shed light on the structure of economic activity in Canada. We have been able to quantify the extent to which the Atlantic Provinces as distinct economies are more open than the Rest of Canada and furthermore to establish the precise nature of the real economic links between each of the Atlantic Provinces and the Rest of Canada. Let us evaluate government programs of subsidizing industrial development in the Maritimes in light of the results reported in Section 2. In the recent past the Area Development Agency (ADA) and the Atlantic Development Board (ADB) have been the chief instruments of federal government activity in this sphere.[11] In addition, we will examine some economic implications of subsidizing the flow of goods travelling by rail within and from the Maritime Provinces. Such a program has been in effect under the authority of the Maritimes Freight Rates Act.[12]

We observed the existence of substantial leakages of economic activity from the Atlantic regions to the Rest of Canada, particularly into sectors 6 and 7 involved with fabrication from sectors 4, 6 and 7 in the Maritimes dealing with fabrication and with mining. Details are contained in Table A1 in the Appendix. Reverse leakages were, relatively, much smaller. Investments which require fabricated inputs will have these high leakages out of the Atlantic regions. The emphasis of the ADA on the expansion of secondary manufacturing in order to increase employment and incomes should recognize these high leakages. In the parlance of Hirschman,[13] although the backward linkages of these investments may be high, they tend to be centred on the Rest of Canada. The pressures on existing capacity will be felt in Central Canada rather than in the Maritimes and to the extent that entrepreneurs respond to the pressures by undertaking investment in new capacity, the increases in investment and in economic activity in general will center largely in Central Canada. Furthermore, the available evidence on the efficiency of existing manufacturing industries in the Maritimes[14] leads one to predict that even if direct subsidies to new manufacturing industries locating in the Maritimes are effective in attracting new industries which would, in the absence of subsidies, locate elsewhere, the new productive capacity in the Maritimes will not be efficient. Efficiency is used here to mean that the plant is producing in a sufficiently large volume of output so as to have reached a point of minimum average cost per unit output in the long run. In other words, the scale of output is such that all benefits of increasing returns to scale have been exploited by the plant.[15]

The transportation subsidies to Atlantic exports to the Rest of Canada and to shipments within the Maritimes make for a larger market for Maritime products, but this artificial expansion of the market has proved to be insufficient to induce the establishment of efficiently sized plants for most secondary industries.[16] If transportation subsidies are designed to expand the potential market for secondary products of the Atlantic regions, and thus to encourage efficiently sized firms to locate in the Maritimes, the scheme has inherent contradictions. In order to operate an efficiently sized plant in the Maritimes intermediate inputs either must be available locally or their importation must be subsidized. The one-sided policy of expanding the market for final products will probably be an excessively weak stimulus to the inducement of entrepreneurs to build and operate efficiently sized plants, since there will be a counteracting force of relatively high costs for intermediate inputs forcing entrepreneurs to operate small high-unit-cost plants. This latter situation which exists in the Maritimes has been in part the product of the particular transportation subsidy policy. The fact that intermediate inputs for secondary industry tend to be imported from the Rest of Canada is clear from the evidence in Tables A1 and 4.

Parenthetically, there seem to be no rational grounds for applying transportation taxes on the flow of intermediate and final products to the Maritimes in order to permit infant industries to mature there. It appears in light of Eastman and Stykolt's results, that a market of 2½ million people is too small to support efficiently sized plants in a broad range of manufactures. It is conceivable that the above taxes, plus subsidies to the transport of final products outside the Maritimes would lead to the establishment of Maritime suppliers and of efficiently sized industries.

Whether the direct transfer of part of the value of the subsidies to Maritime residents, combined with the establishment of the industry in, say, central Canada, could achieve the desired income transfer at less real cost is the alternative to examine.

A final consideration for regional development which is clarified by our empirical results is that backwash or interregional effects from the Rest of Canada to the Maritimes are generally small and should not be relied upon to automatically bring the Atlantic regions into the mainstream of economic growth. It has been suggested that the best way to combat unemployment in particular areas or sectors is to maintain high levels of aggregate demand in the economy as a whole. Our results indicate that there are weak real economic links from the Rest of Canada to the Atlantic regions, so that vigorous increases in activity in the Rest of Canada will be weakly felt in terms of increases of activity in the Atlantic regions where weak is defined relative to the size of the effects in the Rest of Canada. Moreover, our empirical results indicate that there is not one sector in the Maritimes firmly linked to activity in the Rest of Canada. A generalization of the Hirschman linkage criterion for investment determination[17] for interregional analysis is, as we have previously touched upon, a) that the interregional links must be high from the region where the investment is being made to the depressed region, or b) interregional links should be low from the depressed region where the investment is being made to other regions.

APPENDIX

The six different columns for regions correspond to the effects from the separate six different experiments. The sixteen rows for each region correspond to the sixteen sectors or commodities into which each regional economy has been divided.

The results in Table A1 give a detailed picture of the effects of say a fixed rate of growth in all sectors over a period of time. The results can be divided by 10 to give a 10 per cent increase in all sectors rather than the 100 per cent increase for which they were computed. Since we have in fact changed final demands by 100% in the first experiment, we are actually replicating the gross outputs observed when the coefficients were estimated. A 100% change in final demands generates a 100% change in gross outputs. The conditional elasticities of gross outputs with respect to final demands are, then, all unity. They will be different in experiments two through six since only one region's final demands are being changed at a time but the division of any value in parts 2 to 6 of Table A1 by the corresponding value in part 1 will produce a conditional elasticity. These elasticities are conditional on the values of the changes in final demands made concurrently in sectors not being scrutinized at a particular instant.

The results tabulated for the effects of different constellations of final demands on the Outside World are essentially different from those tabulated for the five Canadian regions. The results for the Outside World are simply imports to Canada as a whole classified by sector which are generated by various final demands. The results for each of the other regions are activity levels or gross outputs which include flows to meet indirect demands which are both intersectoral and interregional in nature

Table A1

Activity Levels (Imports for Outside World) Generated From Per Centage Changes in Final Demands in Six Experiments

1. Final Demands set at 100% for all sectors in Five Regions

SECTOR	REST OF CDA	NEW BRUNSWICK	NOVA SCOTIA	NEWFOUNDLAND	PRINCE EDWARD	OUTS WORLD
1. Agriculture	5905.395	158.381	146.127	22.286	62.988	304.254
2. Forestry	791.136	48.132	23.761	36.610	2.046	22.856
3. Fishing	203.475	37.590	84.979	49.250	13.157	3.302
4. Mining, drilling, quarrying	4734.164	23.990	107.853	91.433	0.137	441.912
5. Food processing	6439.458	522.996	276.298	87.848	53.572	4044.785
6. Iron reduction and fabricating	6643.229	62.616	144.862	33.960	4.107	1901.342
7. Fabricating*	16992.011	129.374	193.551	35.975	10.821	2852.494
8. Sawmills and other wood industries	1235.909	39.861	36.237	6.032	1.861	48.834
9. Pulp and paper mills	2270.172	125.689	23.915	69.353	4.700	95.352
10. Fish processing	193.820	134.140	165.196	46.208	18.093	20.500
11. Residential construction	2021.139	59.449	88.111	50.043	7.223	0.000
12. Non-residential construction	4704.144	109.773	182.186	108.995	29.398	0.000
13. Transportation	15617.221	214.564	239.320	143.707	25.297	2.723
14. Radio broadcasting, electric power, gas and water	4388.974	91.590	110.384	35.733	9.613	0.000
15. Trade and tertiary services	16782.043	814.417	1006.481	440.010	123.373	0.000
16. Households	29252.280	836.841	976.815	490.136	121.699	0.000

* including petroleum refining, printing and publishing, yarn and cloth mills, clothing, miscellaneous wood industries.

2. Final Demands set at 100% for all Sectors in Rest of Canada

SECTOR	REST OF CDA	NEW BRUNSWICK	NOVA SCOTIA	NEWFOUNDLAND	PRINCE EDWARD	OUTS WORLD
1	5857.507	71.922	23.288	0.849	16.266	280.339
2	782.876	11.015	2.191	0.339	0.885	17.619
3	195.777	5.097	7.578	5.596	3.761	1.884
4	4712.218	13.023	62.873	22.275	0.010	438.710
5	6349.699	349.962	75.545	1.398	10.896	3949.094
6	6519.984	15.137	46.192	0.749	0.041	1800.586
7	16844.407	41.480	53.300	2.509	3.310	2732.327
8	1226.707	8.961	2.828	0.134	0.210	37.802
9	2259.928	34.627	1.391	0.060	0.000	94.528
10	191.904	18.206	14.034	6.770	6.307	15.987
11	2017.919	12.428	4.460	0.688	0.353	0.000
12	4698.413	0.551	7.428	0.721	0.916	0.000
13	15538.809	84.004	59.650	8.601	5.188	0.189
14	4366.515	24.076	19.154	1.735	1.557	0.000
15	16710.422	177.388	126.763	15.450	15.481	0.000
16	29047.574	248.747	175.893	25.107	22.246	0.000

Table A1 Cont'd

3. Final Demands set at 100% for all Sectors in New Brunswick

SECTOR/REST OF CDA		NEW BRUNSWICK	NOVA SCOTIA	NEWFOUNDLAND	PRINCE EDWARD	OUTS WORLD
1	10.697	80.886	4.466	0.028	1.698	4.611
2	4.711	35.247	0.756	0.030	0.098	3.835
3	6.851	32.039	11.175	0.715	2.408	1.386
4	6.516	10.568	2.684	0.082	0.002	0.912
5	16.902	148.689	4.373	0.085	1.458	22.858
6	34.412	46.652	1.621	0.031	0.006	30.364
7	45.715	69.204	23.223	0.339	0.939	39.685
8	3.576	27.682	1.235	0.010	0.476	1.506
9	3.788	83.664	0.404	0.027	0.000	0.317
10	0.310	114.315	1.792	0.863	0.163	1.131
11	0.926	45.923	0.568	0.031	0.052	0.000
12	1.585	109.169	1.428	0.031	0.110	0.000
13	21.231	125.291	3.684	0.235	0.461	0.006
14	6.478	65.407	2.750	0.065	0.172	0.000
15	20.579	620.605	16.112	0.695	2.295	0.000
16	59.876	563.296	24.668	1.342	3.804	0.000

4. Final Demands set at 100% for all Sectors in Nova Scotia

SECTOR/REST OF CDA		NEW BRUNSWICK	NOVA SCOTIA	NEWFOUNDLAND	PRINCE EDWARD	OUTS WORLD
1	19.758	3.465	115.051	0.490	7.479	12.138
2	1.724	0.853	19.769	0.442	0.248	0.444
3	0.548	0.199	65.741	23.901	0.314	0.017
4	9.888	0.250	41.385	1.101	0.005	1.411
5	31.252	15.937	191.881	1.772	5.296	49.303
6	58.935	0.547	94.910	0.136	0.015	41.666
7	68.815	15.787	112.613	0.854	2.015	50.679
8	2.654	0.926	28.781	0.096	0.042	6.863
9	3.619	4.094	22.043	0.021	0.000	0.294
10	1.107	0.712	148.414	0.668	0.557	2.670
11	1.346	0.731	82.855	0.527	0.114	0.000
12	2.392	0.032	172.886	0.407	0.337	0.000
13	31.679	3.476	174.428	3.534	1.028	0.089
14	9.607	1.378	87.680	0.846	0.408	0.000
15	29.944	10.776	857.163	11.798	4.972	0.000
16	85.143	16.158	766.570	24.120	7.552	0.000

Table Al Cont'd

5. Final Demands set at 100% for all Sectors in Newfoundland

SECTOR/REST OF CDA		NEW BRUNSWICK	NOVA SCOTIA	NEWFOUNDLAND	PRINCE EDWARD	OUTS WORLD
1	14.909	1.531	2.918	20.896	4.633	6.478
2	1.210	0.826	0.790	35.759	0.021	0.454
3	0.199	0.206	0.309	18.826	0.036	0.011
4	4.954	0.129	0.800	67.949	0.002	0.804
5	38.067	5.407	3.594	84.526	4.397	20.390
6	26.664	0.241	1.428	33.035	0.050	24.514
7	29.765	0.934	3.741	30.762	0.426	27.861
8	2.245	1.608	2.554	5.771	0.028	2.495
9	2.563	3.155	0.064	69.220	0.000	0.191
10	0.271	0.737	0.573	37.603	0.039	0.625
11	0.844	0.253	0.184	48.767	0.066	0.000
12	1.559	0.016	0.359	107.806	0.196	0.000
13	22.999	1.245	1.262	131.107	0.605	2.433
14	5.682	0.522	0.647	33.019	0.237	0.000
15	18.766	3.943	5.214	411.379	2.889	0.000
16	52.935	6.056	7.777	438.295	4.343	0.000

6. Final Demands set at 100% for all Sectors in Prince Edward I.

SECTOR/REST OF CDA		NEW BRUNSWICK	NOVA SCOTIA	NEWFOUNDLAND	PRINCE EDWARD	OUTS WORLD
1	2.525	0.578	0.405	0.023	32.911	0.688
2	0.615	0.191	0.255	0.040	0.795	0.505
3	0.100	0.048	0.177	0.212	6.638	0.004
4	0.589	0.020	0.110	0.025	0.118	0.074
5	3.539	3.001	0.505	0.067	31.525	3.140
6	3.236	0.040	0.710	0.009	3.996	4.213
7	3.312	1.969	0.674	1.511	4.131	1.943
8	0.727	0.685	0.839	0.021	1.105	0.168
9	0.273	0.149	0.012	0.024	4.700	0.022
10	0.228	0.171	0.383	0.303	11.026	0.087
11	0.105	0.114	0.043	0.031	6.638	0.000
12	0.195	0.006	0.085	0.031	27.839	0.000
13	2.503	0.549	0.296	0.230	18.016	0.006
14	0.691	0.208	0.154	0.068	7.240	0.000
15	2.333	1.705	1.228	0.688	97.737	0.000
16	6.753	2.582	1.907	1.272	83.755	0.000

and final or direct demands which are exogenously determined. Imports from the Outside World by sector to separate regions can easily be determined by taking the final activity level vector for any one region and multiplying that particular region's matrix of technical coefficients weighted by the supply coefficients for the Outside World which were derived for the region in question. It is possible to derive these data so easily because the Outside World is exogenous to the interregional input-output model and is simply appended to the main structure in the same way primary factor requirements are appended to unitary or national Leontief models. Another way of expressing the nature of the Outside World in this structure is to say that there are no feedbacks from the Outside World to the Canadian regions arising from the economic activity in the Canadian regions impinging on the Outside World in the form of required imports to the Canadian regions.

Table A2 contains final demands for the five Canadian regions studied for the year 1960. These final demands are net of exports of each region to the other four regions.

TABLE A2

Final Demands Net of Interregional Exports for 1960

	Sector \ Region	R of C[1]	NB[2]	NS[2]	Nfld[2]	PEI[2]
		(millions of dollars)				
1.	Agriculture	2361.9	30.5	44.0	11.5	14.0
2.	Forestry	42.3	16.9	5.9	11.2	.6
3.	Fishing	92.5	0.0	3.0	0.0	.7
4.	Mining, drilling, quarrying	1575.5	4.9	19.1	65.8	0.0
5.	Food processing	4214.6	106.5	125.5	61.2	22.5
6.	Iron reduction and fabricating	2384.8	38.9	80.5	28.9	3.8
7.	Fabricating*	5716.4	24.0	50.9	21.2	.5
8.	Sawmills and other wood industries	562.6	13.5	6.3	0.4	0.0
9.	Pulp and paper mills	1090.7	79.6	19.4	68.3	4.7
10.	Fish processing	148.0	109.4	142.8	33.7	10.4
11.	Residential construction	1264.3	25.1	52.6	30.4	4.4
12.	Non-residential construction	3755.7	107.3	145.1	97.1	25.0
13.	Transportation	5260.4	29.1	46.2	34.7	5.2
14.	Radio broadcasting, electric power, gas and water	929.2	22.1	27.8	8.1	2.5
15.	Trade and tertiary services	6035.2	252.9	337.7	151.1	38.8
	TOTAL	35,434.1	860.7	1106.8	623.5	133.1

1. Source of data is published data from Dominion Bureau of Statistics altered with results from Professor Kari Levitt's Maritime Input-Output Accounts. See the Appendix to Chapter III of J. Hartwick, Ph.D. dissertation, op. cit.

2. Maritime Input-Output Study is source of data.

*including petroleum refining, printing and publishing, yarn and cloth mills, clothing, miscellaneous wood industries.

FOOTNOTES

[1]H.B. Chenery, P. G. Clark, and Vera Cao Pinna, The Structure and Growth of the Italian Economy, United Stated Mutual Security Agency, Rome, 1953, Chapter 5 by Chenery.

Leon N. Moses, "The Stability of Interregional Trading Patterns and Input-Output Analysis", American Economic Review, Vol. XLV, No. 5, December 1955.

[2]The assumptions are discussed in Moses, op. cit. and from a different perspective by Earl O. Heady and H. O. Carter, "Input-Output Models as Techniques in the Analysis of Interregional Competition", Journal of Farm Economics, Vol. 41, 1960 pp. 978-991.

[3]Matrix A and vectors x and y are n-dimensional where n is the number of sectors in one region. Matrix A^I, and vectors x^I and y^I will be nm dimensional where n is the number of sectors and m the number of regions. I and I^I are the correspondingly dimensioned identity matrices.

[4]See for example S. E. Chernick, Interregional Disparities in Income, Economic Council of Canada, Ottawa, 1966; or Marvin McInnis, "The Trend of Regional Income Differentials in Canada", Canadian Journal of Economics, I, No. 2, May 1968, pp. 440-470.

[5]Dr. Levitt presented her first analysis of the Atlantic economies based on her input-output tables at the Canadian Economics Association Meeting at York University, June 6, 1969. (Kari Levitt, "A Macro Economic Analysis of the Structure of the Economy of the Atlantic Provinces, 1960"). She developed transformation matrices in order to convert results derived from an input-output framework into a National Accounting framework and thus was able to perform what she calls a macro analysis as opposed to the conventional input-output or micro analysis. She worked with four separate regional systems for the four Canadian Atlantic Provinces as opposed to an integrated interregional system like the one used in this study. Her analysis nicely complements the one reported here. She performs a detailed analysis of the openness of each economy to external trade along National Accounting lines and finds the Atlantic Provinces "highly dependent on export sales". The reference point is with regard to the magnitudes of other components of provincial product rather than to the magnitudes of exports in other regions such as the Rest of Canada, the benchmark used in this study. She also ascertains that the Atlantic economies are "highly dependent on public sector expenditures". This interesting conclusion could not be determined in an analysis which is based solely on the input-output accounting framework as is the one reported below.

[6]This type of model was proposed by W. Isard, "Interregional and Regional Input-Output Analysis; A Model of a Space Economy", Review of Economics and Statistics, Vol. XXXIII, No. 4, 1951. In my Ph.D. thesis, (Johns Hopkins University, 1969) I have made a precise comparison of the algebraic formulation of the Chenery-Moses and the Isard models and revealed the approximations inherent in the Chenery-Moses model which requires considerably less data to be statistically implemented.

Wassily Leontief and Alan Strout in "Multi-Regional Input-Output Analysis", in Tibor Barna, ed. Structural Interdependence and Economic Development, McMillan, London, 1963, have developed algorithms for statistically implementing interregional input-output models when neither the regions of origin of imports or the regions of destination of exports are known for the sectoral flows.

[7]A detailed exposition of the procedures followed in preparing the principal matrix A^I is contained in my dissertation, "Regional Analysis by Means of Interregional Input-Output Models", Johns Hopkins University, 1969, Chapter 3.

[8]Insofar as imports from the Outside World by Canada generate feedback effects in the form of imports to the Outside World elicited by increased activity in the Outside World, the assumption of exogeneity is faulty. In 1968, the "Outside World" consisted substantially of the United States, since about 67% of Canada's exports went there and 75% of Canada's imports originated there. However, the United States' trade position vis-a-vis Canada was as follows: 23% of their total exports went to Canada and 25% of their imports originated in Canada. It does not seem unreasonable to assume that the multiplier effects of Canada's imports from the U.S. on U.S. gross national product are small, which in turn implies small feedback effects from the U.S. to Canada, resulting from those original multiplier effects. Effects would be larger if most U.S.-Canada trade took place in regions along the U.S. - Canadian border, but tariffs would inhibit such localization of these effects.

[9]See B. W. Wilkinson, Canada's International Trade: An Analysis of Recent Trends and Patterns, (Montreal: Private Planning Association of Canada), 1967, pp. 14-15.

[10]Final demands for the Household sector were observed to be zero and so their 100% increase was again zero.

[11]For a review of these and other regional programs, see T.N. Brewis, Regional Economic Policies in Canada, (Toronto, Macmillan), 1969.

[12]In July, 1969, the Atlantic Region Freight Assistance Act was passed and its stipulations extended Federal Government subsidies to truck and water transportation from the Atlantic region.

[13]See Albert O. Hirschman, The Strategy of Economic Development, (New Haven: Yale University Press), 1958, Chapter 6 for a definition of linkages and their application to selecting an investment strategy.

[14]See H.C. Eastman and S. Stykolt, The Tariff and Competition in Canada, (Toronto: Macmillan), 1967, especially Table 1, pp. 62-63.

[15]The concept I have in mind is that of "minimal optimal plant scale" and was developed in the context of applied economics by Joe S. Bain, Barriers to New Competition, (Cambridge, Mass.: Harvard University Press), 1956, Chapter 3. Eastman and Stykolt, op. cit. appealed to the same measure of efficiency.

[16]See the reference in footnote 14.

[17]Hirschman's criterion alone is only necessary but not necessary and sufficient. High backward linkages can induce further development as Hirschman expects but the initial investment must pass some test of economic efficiency aside from being observed as having high linkages. For example, a steel mill has high linkages but we would not recommend establishing one in Prince Edward Island.